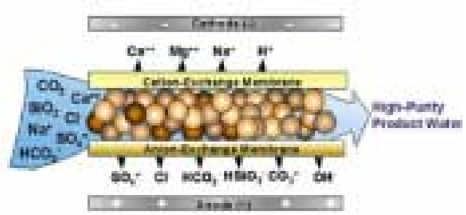
APPLICATION NOTE

Demineralizer

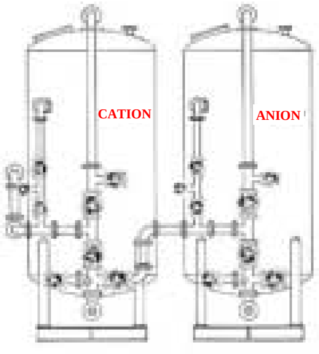
Background Information

Ion Exchange, in chemistry, is a method of replacing ions in a solution with ions of the same charge in certain insoluble substances. This occurs by passing the solution through porous solid materials, usually minerals of the zeolite group or specially prepared synthetic resins (plastics) containing large, complex molecules. Zeolites are a large group of minerals composed of hydrated aluminum silicates of alkali metals and alkaline earth metals. Certain ions in the solution replace ions or groups of ions in the resin or zeolite, from which they can then be washed out during the process of regeneration.

Hardness in water, caused by calcium and magnesium ions, is removed by ion exchange. The water is filtered through an artificial zeolite, and the sodium in the zeolite replaces the undesirable ions that are in the water. When the zeolite is saturated with these metallic ions, it is washed with a salt solution, which restores the sodium.



Ion-exchange resins come from a wide variety of organic and synthetic materials containing positively or negatively charged sites which attract ions of opposite charge from the surrounding solution. The resins commonly consist of a styrene-divinylbenzene copolymer. The electrically charged groups are commonly sulfonic or carboxylic acid salts or quaternary ammonium salts. Polymers containing acid groups are classified as acid or cation, exchangers because they exchange positively charged ions, such as hydrogen ions and metal ions.



Those containing ammonium groups are considered basic or anion exchangers because they exchange negatively charged ions, usually hydroxide ions or halide ions.

Ion-exchange resins are light and porous solids, usually prepared in the form of granules, beads, or sheets. When immersed in solution, the resins absorb the solution and swell. Resins of suitable chemical compositions and physical properties may be synthesized at will for specific ion-exchange applications.

In industrial and domestic applications, ion-exchange resins are used for the removal of calcium, magnesium, iron, and manganese salts from water (water softening), for purification of sugar, and for concentration of valuable elements, such as gold, silver, and uranium from mineral ores. In chemical analysis, ion-exchange resins are used for the separation or concentration of ionic substances.

In chemical synthesis, some ion-exchange resins have been used as effective catalysts, notably in esterification and hydrolysis reactions.

Deionization or de-mineralization is a process that removes dissolved ionic material from water for purification. Deionization takes place in an ion exchange unit, which usually consists of a cation bed, an anion bed and a mixed bed in series. The mixed bed, also referred to as a polisher, contains both cation and anion resins and provides the highest ion removal efficiency.

The cation bed is used to remove positively charged ions such as calcium, magnesium and sodium and the anion bed removes negatively ions such as sulfate and chloride. Specific resins are chosen to optimize bed performance, depending upon the water composition to be purified

Control (regeneration) of the ion exchange unit is accomplished by monitoring the conductivity. Precise control can be achieved in cation and anion beds, by measuring the inlet and outlet conductivity to obtain a ratio. This is referred to as "Across the Bed" monitoring. Comparing the inlet and outlet conductivity identifies when breakthrough occurs (when resins no longer have the capacity to exchange ions) and regeneration is necessary.

Measuring the conductivity in the bed and at the outlet, is referred to as "Within the Bed" monitoring and can signal when regeneration is necessary before breakthrough occurs. "Within the Bed" monitoring is difficult because one of the conductivity sensors must be inserted into the bed taking caution to prevent resin beads from entering the flow path of the sensor and shorting the cells.

During purification, the properties of the water vary at different stages of deionization, requiring a number of temperature compensation algorithms. Raw water typically contains neutral minerals requiring one temperature algorithm, cation exchanged water is acidic requiring another temperature algorithm and deionized water (high purity) is close to neutral and requires yet another temperature algorithm.

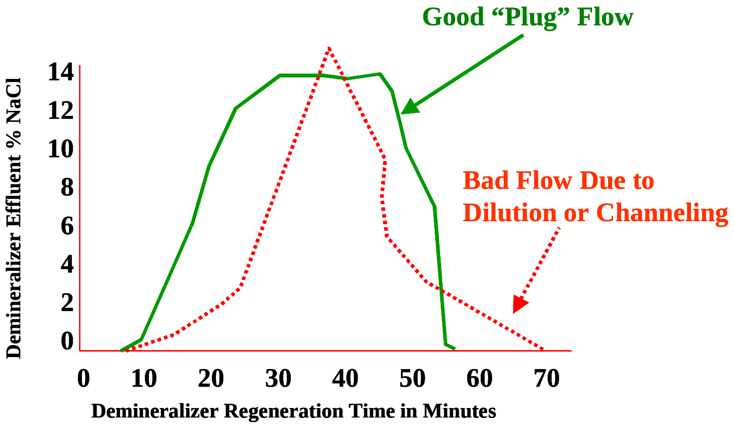
CATION CONDUCTIVITY

"Across the Bed" Monitoring

In a cation exchange bed, cations entering the bed are exchanged with hydrogen ions producing an acidic solution at the outlet. Since the hydrogen ions leaving the bed are more conductive than the cations entering the bed, the conductivity at the outlet will be considerably higher. A high conductivity ratio indicates good mineral ion removal, while a ratio approaching one (1) indicates poor removal. The conductivity (conductance) ratio is expressed as the conductivity of the outlet cell (cell 1) divided by the conductivity of the inlet cell (cell 2). The typical ratio range is 1 - 4.

"Within the Bed" Monitoring

During normal operation of "Within the Bed" monitoring, both conductivity cells will see a high conductivity value as the mineral cations are exchanged for hydrogen ions and the ratio approachs one (1). As the resin is depleted the conductivity value of cell 2 will start to decrease as it comes in contact with the less conductive mineral cations and the ratio will increase. The typical ratio range is 1 - 1.5. A ratio of 1 indicates good system performance and a ratio approaching 1.5 indicates regeneration is necessary. A high ratio alarm can be set to initiate regeneration before mineral breakthrough reaches the outlet.



Evaluation Regeneration Profile. Optimum concurrent regeneration of Sodium exchanger requires the brine discharge to exceed 8% for about 30 minutes.

Any single ion exchanger or demineralizer experiences changes in capacity from one regeneration run to another, because it is difficult to obtain perfect flow distribution with a flat *wave front.* Deviations of 5-10 % are common. A steady falloff of capacity however is a serious matter requiring investigation to determine and correct the cause. One of the most common problems is a gradual loss of material (resins) due to regeneration runs. Periodic bed depth measurements check for this loss.

Dirty ion beds resulting from improper backwash is another problem solved by proper cleaning procedures. Incorrect chemical application will also cause poor resin performance. Determining if there are regeneration problems is relatively easy.

Samples are taken from the bottom port of the Demineralizer at specific and regular intervals. The conductivity of the solution is measured or a % concentration is determined also based upon a conductivity reading. The conductivity (% concentration) is plotted against time (see above).

The dotted line shows poor regeneration characteristics, caused by excessive chemical dilution. The resin beads may also have a channel running through the bed (improper backwash) which prevents an even regenerate contact throughout the resin bead.

The solid line shows the regeneration time at the proper concentration levels.

Recommended Products:

Pure Water Conductivity:

DC402 Dual Channel four-wire Conductivity Converter

SC42-SP34 Conductivity Sensor (fittings available for Flow-Thru, Insertion, or Immersion installations) or

SC4A Conductivity Sensor (fittings available for Insertion, Sanitary, or Retractable installations)

Note: For additional information on these applications, please contact Analytical Product Marketing.